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SmaggIce User Guide

SmaggIce Version 1.0

Marivell Baez, Mary Vickerman, and Yung Choo
Glenn Research Center, Cleveland, Ohio

February 2000

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National Aeronautics and
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What is SmagIce?

SmagIce (Surface Modeling And Grid Generation for Iced Airfoils) is one of NASA's aircraft icing research codes developed at the Glenn Research Center. It is a software toolkit used in the process of aerodynamic performance prediction of iced airfoils. It includes tools which complement the 2D grid-based CFD process:

- geometry probing
- surface preparation for gridding:
smoothing and re-discretization of geometry

Future releases will also include support for all aspects of gridding:

- domain decomposition
- perimeter discretization
- grid generation and modification

Release Information

SmagIce version 1.0 provides two types of software tools: interactive ice shape probing and interactive ice shape control. The ice shape probing tools provide users the means to measure the physical characteristics of ice such as icing limit locations, horn height and angle, and distance from the leading edge to any prominent ice location. The ice shape control features provide the means to examine input geometry data, correct or modify any deficiencies of them, and perform a systematic smoothing of ice to a level that will make the CFD process manageable.

The furnished code is still under development and is furnished as is, with no warranty of fitness for any particular use. You are not permitted to give the SmagIce code to any other organizations and/or persons outside your company. We would be interested in knowing about any problems or

errors that you experience with the codes, as well as any new features you would like to see included in future releases.

Contact Information

Questions and comments can be sent via e-mail to:
smaggice@grc.nasa.gov

Capabilities

Ice Shape Probing

Interactive ice shape probing is used in the process of characterizing ice shapes. Probing involves making measurements of the data on the screen, recording those measurements in a table, and saving them to a file. Once the boundary data is read in, the user may make probing measurements. These include: point location (e.g., ice limits), distance between two points (e.g., ice horn height or width), "arc length" (i.e., the sum of the lengths of the line segments along a boundary between two points on that boundary), angle between two lines (e.g., horn angle), and $(X-X_{le})/C$ (i.e., $(x-x_{LeadingEdge})/chordLength$). Location and distance may be normalized by the chord length of a clean airfoil. The probe points can be selected by various methods: the closest point to any object, the closest point to the current object, the closest point to the reference object, or an arbitrary point in space. Probing information may be saved to a text file and a corresponding graphics display can be saved to an image file.

Ice Shape Control

Interactive ice shape control is used to prepare the surface for gridding. The types of functions that can be applied to surfaces are curve smoothing, discretization, and reshaping. Any subcurve (or the entire curve) of an element can be selected for processing. Systematic smoothing of the iced boundaries in a controlled manner is accomplished using a control point formulation. Users can control the level of smoothing by choosing the number of control points in constructing curves. Curve discretization provides a means of increasing/decreasing the number of points, distributing the points by curvature, and controlling the uniformity of their dis-

tribution. In addition, hyperbolic tangent stretching is provided. Direct reshaping of the curve (to perhaps correct obvious ice shape errors) is done by dragging control points associated with the curve. These control features of Smagglce not only prepare the ice surface for the grid-based CFD, but they also allow users to correct any deficiencies (e.g., tangles, gaps, too many or too few points) in the input data.

Implementation Issues

Smagglce is written in FORTRAN and C. FORTRAN is used for the computational routines; C is used for the GUI, control, interaction, graphics, and memory management.

Smagglce is intended to run on any UNIX platform and has been tested on SGI, Sun, IBM RS6000, and HP systems. The GUI was developed for X-windows, using Motif, Xt Intrinsic, and Xlib functions. This will aid in the portability of the user interface across multiple computer platforms running X. Whenever possible, the GUI uses higher level libraries (Motif widgets) rather than the functionally equivalent Xt or Xlib libraries, because the higher-level code hides many of the details. This makes the code less complex, so the application is more easily maintained.

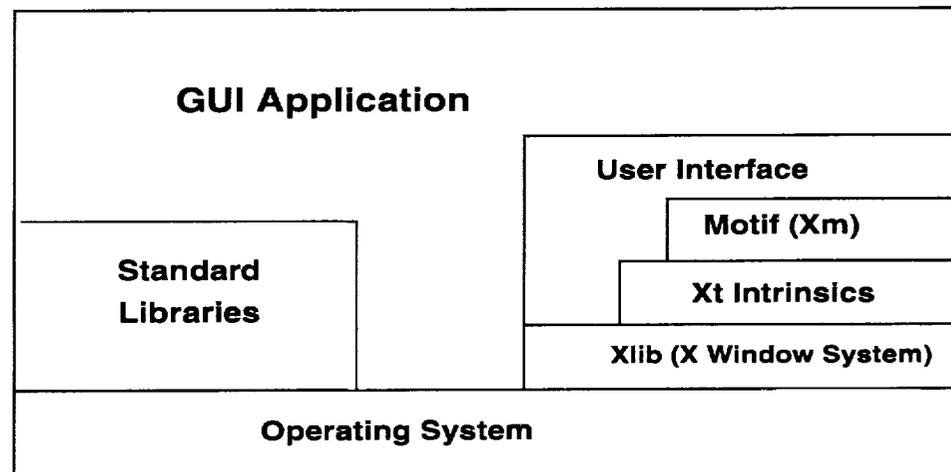


Figure 1. Diagram of the user interface library model.

The GUI provides a graphical mechanism for the user to interact with the data. Some of the Smagglce functionalities which support the primary capabilities are: reading data, displaying 2D graphics objects, performing

geometric transformations (such as translation, scaling, area zoom, zoom in, zoom out), and saving data and images to files.

OpenGL is used for the graphics drawing. It uses the GLX extensions to X to interface with the windowing system, but the Mesa library can be used if the workstation does not have OpenGL or if the X server does not support the GLX extensions.

Dynamic memory management is used to allocate only as much memory as is necessary for data storage and access. This allows the program to process models whose size is limited only by the amount of memory on the host computer. It also allows multiple input files to be read in and processed during a single session. In addition, when data is no longer needed during a session, it can be cleared to allow for reading in new data. The data structures that make use of dynamic memory in Smagg-Ice version 1.0 are illustrated here (Figure 2). As objects are read in, memory is allocated for them to store the object type as well as attributes describing the object. Space is also allocated for the data points defining the geometry, and a pointer stored with the object. When additional objects are read in, or as geometry is modified (e.g., points are added), memory is reallocated as needed. When objects are deleted, the memory is freed to make room for new objects.

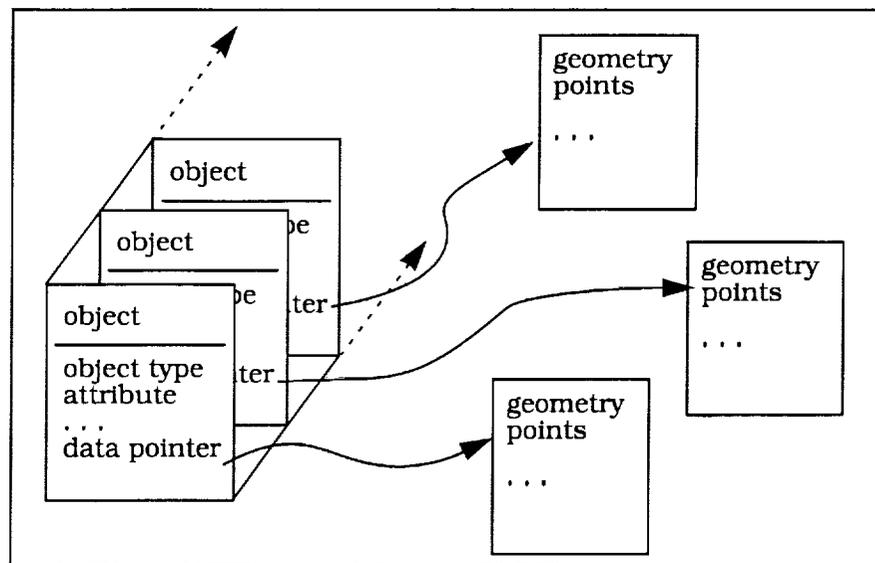


Figure 2. Data structures for multiple objects using dynamic memory.

Access and Installation

How to get SmaggIce

This computer program is available to any U.S. organization upon request. It is furnished on the condition that it will be used only within and for the U.S. organization which requests the software, and that it will not be transmitted to other organizations.

E-mail requests for software should be directed to:
Yung.K.Cho@grc.nasa.gov

System Requirements

SmaggIce was designed and written to run on any Unix platform. It has been built for the following systems:

- SGI Irix 5.3 using X and OpenGL
- SGI Irix 6.5 (32 bit) using X and OpenGL
- SGI Irix 6.5 (32 bit) using X without OpenGL
- SUN SunOS 5.5.1 using X without OpenGL
- IBM RS6000 AIX 4.3 using X and OpenGL
- IBM RS6000 AIX 4.3 using X without OpenGL
- HP-UX 10.20 using X without OpenGL

If you decide to run a version that uses OpenGL, you must have the OpenGL libraries installed on your system.

Currently, SmaggIce is only distributed as a binary executable. If the platform you are using is not listed here, try using one built for an earlier version of the same operating system. In most cases, you can run that successfully. If you need a version of SmaggIce for a platform that is not included in the distribution, please contact the SmaggIce team.

Distribution

SmagglIce is distributed on a CD-ROM. The CD contains:

1. README file with a description of the CD-ROM contents, and directions for installation and startup.
2. Executable SmagglIce version 1.0 for each supported system.
3. Sample input geometry files used in the tutorial.
4. This user manual in Postscript and PDF format.
5. On-line help files in HTML format.
6. Auxiliary files needed to set up and run SmagglIce.

You are not permitted to give the SmagglIce code to any other organizations and/or persons outside your company. We would be interested in knowing about any problems or errors that you experience with the codes, as well as any new features you would like to see included in the future.

If you need additional assistance, please contact the following developers:

Yung K. Choo at (216) 433-5868 or
Mary Vickerman at (216) 433-5067
e-mail: smagglIce@grc.nasa.gov
fax: (216) 977-7469

Installation

1. Copy the contents of the CD-ROM to a local directory. For example:

```
> mkdir $HOME/smagglIce  
> cp -r /CDROM/* $HOME/smagglIce
```

2. Change to that directory and edit the file `bin/runsmagglIce`. Detailed directions are in the file.

You will have to set at least two environmental variables in that file:

SMG_DIR - directory into which the SmagglIce distribution was copied
SMG_VENDOR - the architecture on which you are running

On some systems, you have the option of displaying the graphics using OpenGL or X only (without OpenGL). The default is to run the OpenGL version, if it is available. If you would rather run the X-only version, that option can be set here.

To display on-line help, you may need to set the variable `WEBBROWSER`.

Getting Started

Before starting Smagglce, be sure you have modified the runsmagg script (which can be found in the smaggice/bin directory), as described in step 2 of the Installation instructions.

To run Smagglce, invoke the runsmagg script in the smaggice/bin directory by specifying its full pathname. For example, if you have installed Smagglce in the directory \$HOME/smaggice, type:

```
> $HOME/smaggice/bin/runsmagg
```

Alternatively, you may wish to add the smaggice/bin directory to your path, then simply type:

```
> runsmagg
```

The Smagglce main window will be displayed.

Usage Overview

Smagglce deals with three main types of objects: elements, blocks, and grids. An element is either the entire or partial boundary geometry of a solid or a section of flow domain. For example, an element may be a clean or iced airfoil, or an isolated ice shape between upper and lower ice limits. Elements are typically processed in preparation for gridding to correct input errors, smooth the boundary, increase or decrease the number of points, and/or redistribute the existing points.

Since Smagglce allows you to work with multiple objects, it must necessarily support the concept of a "current object". Details of how to switch between objects and modify those objects are given in the next chapter.

Many Smagglce functions are performed on subcurves of objects. Details of how to select and modify subcurves are also given in the next chapter.

As you begin using Smagglce, you will see that the GUI is designed to provide “directed control” or “guided use”. This means that the user will be prevented, through the desensitization of widgets (menus, buttons, sliders, etc.), from selecting conflicting functions or functions that are invalid in certain situations.

Error checking is performed at all levels, starting at the GUI, whenever the user enters parameters. Any errors such as out-of-range data or invalid values are immediately reported so that the user can correct them.

SmaggIce main window

SmaggIce consists of a primary Main Window titled “SmaggIce - Surface Modeling and Grid Generation for Iced Airfoils” and sub-windows called:

- File Open
- Screen Save
- Save As
- Messages
- Ice Shape Characteristics
- Save Probe Information
- Discretize Subcurve
- Change Free Form Subcurve
- Tanh Redistribution

The SmaggIce Main Window (Figure 3) is recognized by the following distinctive areas: **MenuBar** (*File, Edit, View, Probe, Boundary, Grid-CN, Grid-Direct, Solution, and Help* pulldown menus), **Information, Current Object Info, Graphics Window Mode, View Manipulation, and Graphics Drawing Area**. Those items that are “grayed-out” are not available at this time. Also, sometimes items are “grayed-out” when certain selections have been made. This means that the item is temporarily unavailable. An example of this is the *Save As* or *Screen Save* selection. These are “grayed-out” when the user starts the application, because no data has been read, so there is nothing that can be saved. Similarly, when the user removes the data objects from the graphics window by selecting *Edit->Clear All*, many GUI functions will not be available to the users. This section of the manual will describe each of the functionalities that are currently supported.

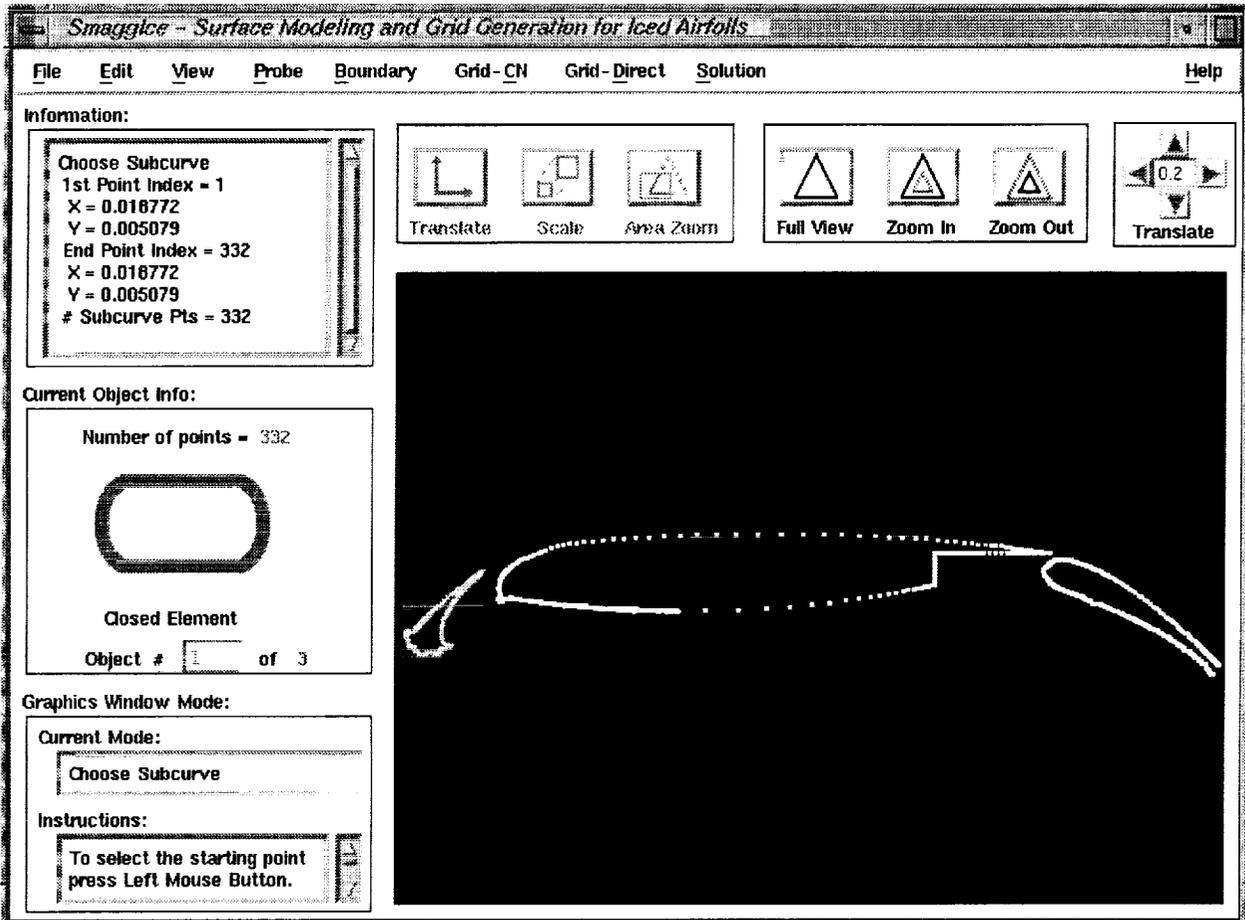


Figure 3. SmagIce Main Window

MenuBar

There are nine menu items in the MenuBar: *File*, *Edit*, *View*, *Probe*, *Boundary*, *Grid-CN*, *Grid-Direct*, *Solution*, and *Help*. Each of these will be described later in the manual section titled "MenuBar" (p. 15).

Information

While the user interacts with the graphics window, relevant information is displayed in the scrollable text area (Figure 4). For example, while probing, the coordinates of points are displayed here. As another example, when a subcurve is being selected, information on the subcurve endpoints is displayed here.

Information:

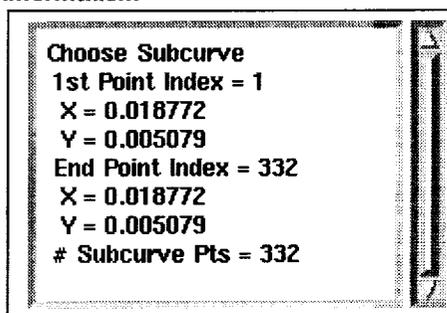


Figure 4. Information

Current Object Info

This area displays information about the current object such as: the type of object, its index number, and a graphics diagram specifying the object depending on its type (Figure 5). For example, when an element is selected, the number of points in the element is displayed, along with an indication of whether it is an open element or closed element. To switch to another object, making it the current object, you may type its index in the **Object #** text box and press <Enter>. Also, there is a non-editable textfield that contains the total number of objects that are currently available.

Current Object Info:

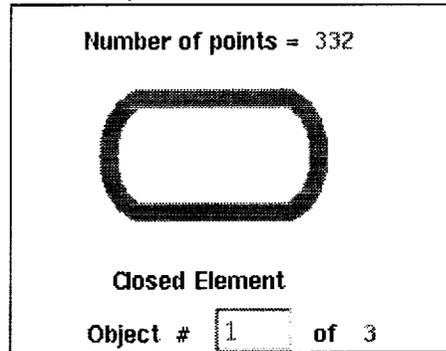


Figure 5. Current Object Info

Graphics Window Mode

The current mode is displayed here, along with instructions (Figure 6). Some of the graphics window modes are: Translate, Scale, Area Zoom, Choose Subcurve, and Display Point Coordinates. Depending on the mode, mouse movements and button clicks will have different effects. How to use the mouse in each mode is described in the **Instructions** scrollable text area.

Graphics Window Mode:

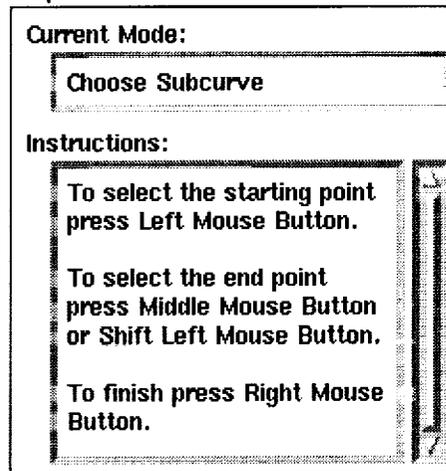


Figure 6. Graphics Window Mode

View Manipulation

These icon push buttons (Figure 7) modify your view of the geometry without changing the data itself. The first set of buttons, labeled **[Translate]**, **[Scale]**, and **[Area Zoom]**, set the mouse mode so that mouse button presses and movements modify the view continuously. **[Translate]** moves the geometry around on the screen without changing its size. **[Scale]** changes the apparent size of the geometry. **[Area Zoom]** allows you to draw a box around an area of interest and zoom into that area. Instructions for how to use the mouse in each instance is displayed in the *Instructions* scrollable text area in the Graphics Window Mode area. The second set of buttons, labeled **[Full View]**, **[Zoom In]**, and **[Zoom Out]**, change the view immediately when you press one of them. **[Full View]** modifies the view to include all geometry. **[Zoom In]** makes all geometry appear a little larger. **[Zoom Out]** makes all geometry appear a little smaller. The last set of arrow buttons labeled **Translate** also changes the view immediately. When an arrow button is pressed, it will move the geometry the indicated fraction of the screen width in that direction. The fraction value may be changed by typing in another value in the textfield. The default fraction is 0.2.

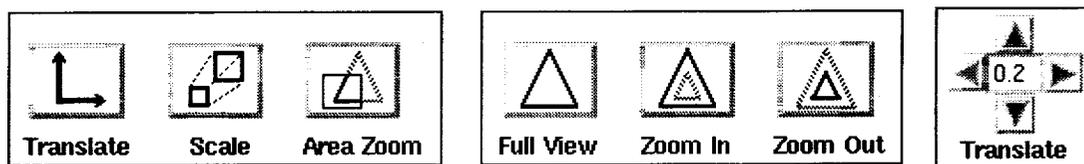


Figure 7. View Manipulation

Graphics Drawing Area

The Graphics area is where geometry is displayed and direct interactive manipulation of the geometry is performed. Depending on the current graphics mode, mouse button presses and movements will have different effects. Instructions for interactions in each mode is described in the **Instructions** scrollable text area in the **Graphics Window Mode** area.

MenuBar

This section gives information on the nine components of the MenuBar: *File*, *Edit*, *View*, *Probe*, *Boundary*, *Grid-CN*, *Grid-Direct*, *Solution*, and *Help*.

File

Currently, there are four actions that can be selected from the File Menu. They are *Open*, *Save As*, *Screen Save*, and *Exit* (Figure 8).

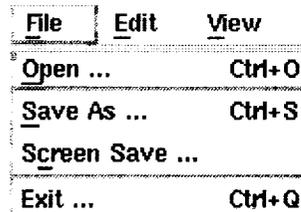


Figure 8. File pulldown menu

Open ... Displays the **File Open** window (Figure 18, p. 23). This window allows the user to select and read the geometry or solution file. More information is available under the section "File Open window" (p. 22).

Save As ... Displays the **Save As** window (Figure 19, p. 25). This window allows the user to save the geometry of objects to a file. More information is available under the section "Save As window" (p. 24).

Screen Save ... Displays the **Screen Save** window (Figure 20, p. 26). This window allows the user to save the Graphics Window as an image file. More information is available under the section "Screen Save window" (p. 26).

Exit ... Presents a confirmation screen to either terminate the Smagglce application or continue in the previous mode.

Edit

Currently, the only option available is *Clear All* (Figure 9).

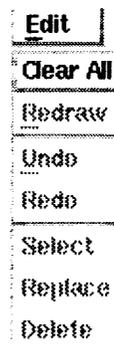


Figure 9. Edit pulldown menu

Clear All - Removes all the data objects from the Graphics Window and sets most of the attributes of SmagIce back to their initial state, as when the program started.

View

This menu allows the user to access the following: *Messages*, *Display Point Coordinates*, *Highlight Tangle*, *Control Net*, *Grid*, *Solution*, and *Messages* (Figure 10).

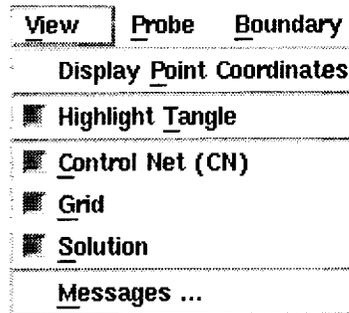


Figure 10. View pulldown menu

Display Point Coordinates - Once the user has selected this option, the graphics mode will be changed to "Display Point Coordinates", so that each left mouse button press in the graphics window will select the closest boundary point in the current object. The point will be highlighted in the graphics display, and its index and (x,y) coordinates will be displayed in the Information section. Instructions for selecting the closest point with the mouse button will be displayed in the **Instruction** scrollable text area in the **Graphics Window Mode** section of the main screen.

Highlight Tangle - Highlights tangles (intersecting lines along the boundary) in elements. When an element is read in and after it is modified in the **Change Free Form Subcurve** window, a search is made for tangles in that element. Up to 25 intersections may be found. If this check box is selected, the intersecting line segments will be highlighted, and a box will be drawn around the point of intersection. If the curve is later modified so as to remove the tangle, the highlighted lines and box will be removed.

Control Net (CN) - Sets the visibility of the control net to be "On" or "Off". This setting currently has no effect.

Grid - Sets the visibility of the grid to be "On" or "Off". This setting currently has no effect.

Solution - Sets the visibility of the solution data to be "On" or "Off". This setting currently has no effect.

Messages ... Displays the **Messages** window (Figure 11). This scrollable window keeps a running log of information, warning, and error messages.

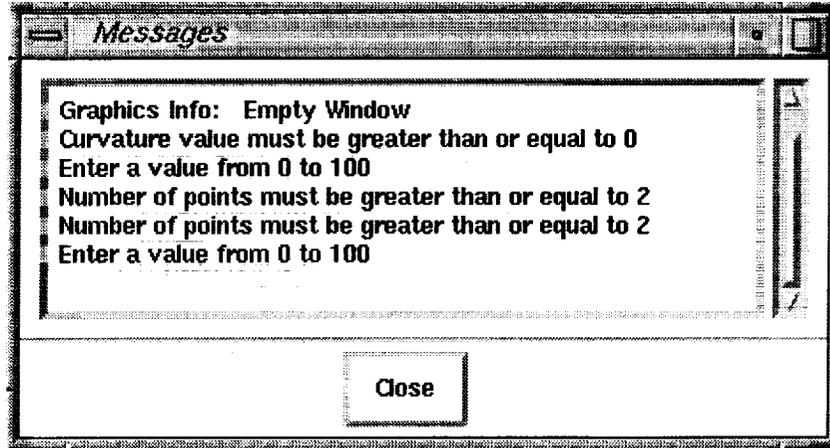


Figure 11. Messages

Probe

This menu allows the user to access the following: *Ice Shape Characteristics*, *Set Reference Airfoil*, *Highlight Reference Airfoil*, and *Display Glyphs* (Figure 12).

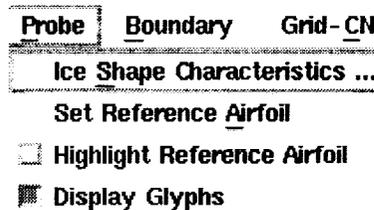


Figure 12. Probe pulldown menu

Ice Shape Characteristics - Displays the **Ice Shape Characteristics** window (Figure 21, p. 27). This window allows the user to probe geometry measurements (such as, location, length, arc length, angle, and (X-Xle)/C) for various point selection methods (such as, all objects, current object, interpolated, reference airfoil, and arbitrary point).

The user can enter the probe information in the Probe Table, and save the probe information to a file. More information is available under the section "Ice Shape Characteristics window" (p. 26).

Set Reference Airfoil - Identifies the current object as the reference airfoil. In order to request some probing measurements, such as normalized length or $(X-X_{le})/C$, a reference airfoil (usually one without ice accretion) must be specified so that the chord length can be calculated and the leading edge can be identified.

Highlight Reference Airfoil - Sets the visibility of the reference airfoil to be "On"/"Off". If a reference airfoil has been set and this toggle is checked (i.e., the box is colored), the reference airfoil will be highlighted. Two additional reference points will also be displayed and selectable during probing operations: the leading edge point, and the center of the leading edge circle. If this toggle is not checked, the reference airfoil will be displayed in the same colors as all other objects, and the two additional reference points will not be displayed or selectable. To set the reference airfoil, make the reference airfoil the current object, and then select *Probe->Set Reference Airfoil* from the main menu.

Display Glyphs - Sets the visibility of the probing glyphs "On" or "Off". If this toggle is checked (i.e., the box is colored), then glyphs (lines and points representing measurements that are entered in the Probe Table) will be shown in the graphics display area, overlaid on the geometry. Turning off this toggle will turn off the display of these glyphs. However, the glyphs will continue to be defined (and displayable by setting the toggle on again), until *Edit->Clear All* is chosen from the main menu, or the **[Clear All]** button is pressed on the *Ice Shape Characteristics* window.

Boundary

Currently, there are five actions that can be selected from the Boundary Menu. They are *Choose Subcurve*, *Discretize Subcurve*, *Change Free Form Subcurve*, *Tanh Redistribution*, and *Switch Object*.

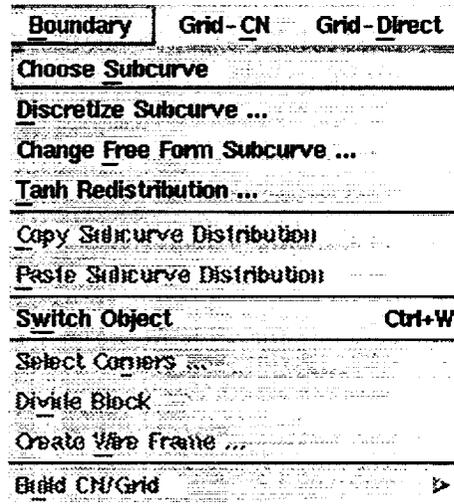


Figure 13. Boundary pulldown menu

Choose Subcurve - Selects the subcurve for the current object. By default, when a boundary is read in, the subcurve is the entire boundary. Several functions in Smaglice (such as *Discretize Subcurve*, *Change Free Form Subcurve*, and *Tanh Redistribution*) are performed on "subcurves". Instructions for setting the endpoints of the subcurve will be displayed in the **Instructions** scrollable text area in the **Graphics Window Mode** area of the main screen.

Discretize Subcurve - Displays the *Discretize Subcurve* window (Figure 22, p. 30). This window allows the user to discretize the selected subcurve of the current object. The new discretized points are displayed as blue crosses overlaid on the graphics display. More information is available under the section "Discretize Subcurve window" (p. 30).

Change Free Form Subcurve - Displays the *Change Free Form Subcurve* window (Figure 23, p. 31). This window allows the user to change the shape of the selected subcurve by using control points. More information is available under the section "Change Free Form Subcurve window" (p. 31).

Tanh Redistribution - Displays the *Tanh Redistribution* window (Figure 24, p. 32). This window allows the user to redistribute the points of the selected subcurve of the current object using a hyperbolic tangent redistribution method. The new point locations are displayed as blue crosses overlaid on the graphics display. More information is available under the section "Tanh Redistribution window" (p. 32).

Switch Object - Makes the next object in the list the current one. SmagIce has the concept of a "current object", which is the object upon which functions are performed. This menu selection allows you to switch to the next object in the list of available objects. The hot key for this menu pick is <Ctrl>W. You may also switch to another object by typing the object number into the **Object #** text box in the **Current Object Info** area of the main screen and pressing <Enter>.

Grid-CN

Currently, all the items in this menu are unavailable.

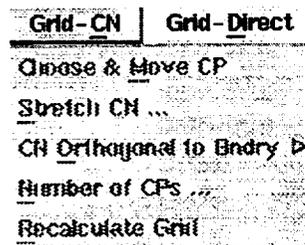


Figure 14. Grid-CN pulldown menu

Grid-Direct

Currently, all the items in this menu are unavailable.



Figure 15. Grid-Direct pulldown menu

Solution

Currently, all the items in this menu are unavailable.

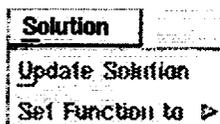


Figure 16. Solution pulldown menu

Help

This menu allows the user to access the following: *On Verston ...* , *Online Help ...* , and *Hints ...* (Figure 17).

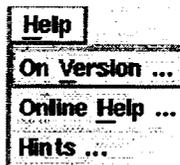


Figure 17. Help pulldown menu

On Verston ... Displays the following information: Smagglce Version, Release date, Copyright, and e-mail address of the contact person.

Online Help ... Displays online HTML documentation

Hints ... Lists the most frequently asked questions.

File Open window

The File Open Window allows the user to select and read geometry and solution data (Figure 18). The user selects from the **File Type** option menu the type of data to be read in. There are four file types available: *Element Boundary*, *Block Boundary*, *Grid*, and *Solution*. An element is an object boundary. There are two different kinds of element boundaries. An open element has the first and last points at different x,y coordinates. A closed element has the first and last points at the same x,y coordinates. The user also selects from the **File Format** option menu the format of the file to be read in. There are three file format types available: *Formatted*, *Unformatted*, and *Binary*. Detailed descriptions of these file formats can be displayed by pressing the [Help] button in this window. Formatted files contain ASCII data and can be created with a text editor or by writing the

data using formatted *write* in a Fortran program or the *printf* function in a C program. Formatted files may also have blank lines and embedded comments; everything on the line after a # is ignored. Unformatted files contain binary data in records, where each record contains information about the record length. These files are normally written using an unformatted *write* in a Fortran program. Binary files contain binary data written as a stream of data. These files are normally written using the *fwrite* function in a C program.

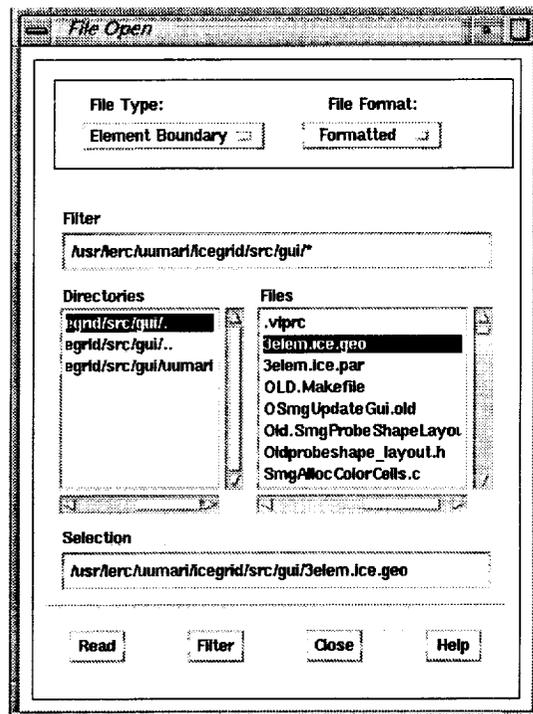


Figure 18. File Open Window

The following controls are used to specify the file to be read: **Filter**, **Directory**, **Files**, and **Selection**.

Filter - Filters or limits the filenames displayed in the **Files** list box. The directory initially displayed in this input box is the current directory (the one you were in when you started the application). You may also type directly into the **Filter** text box the full path followed by a filename which may include an * to match any string of characters. Then press the [**Filter**] button at the bottom of the window.

- Directories** - Lists the directories matching the pattern in the **Filter** input box. If more names exist than can be displayed in the list box, the scrollbar will allow you to move through the list. You can navigate through directories by double-clicking on an entry in this scroll list.
- Files** - Lists the filenames matching the pattern in the **Filter** input box. If more names exist than can be displayed in the list box, the scrollbar will allow you to move through the list. Select a filename from this list by clicking on it or read the file by double-clicking its filename.
- Selection** - Displays the path and filename of the file you want to read. If the desired filename is not displayed, use **Filter**, **Directories**, and **Files** to select the desired filename or type the name of the path and file you want in this area. If the **Selection** input box already contains a name, you can edit the name as you would in any input box. Pressing <Enter> after typing the filename is equivalent to clicking the **[Read]** button or double-clicking a filename.

Save As window

The **Save As** window allows saving geometry and solution data to a file. The user selects from the **Save Object** option menu the type of data to be saved. There are five types of data that can be saved: *Current Object*, *All Elements*, *All Blocks*, *All Grids*, and *All Solutions*. The **Save Object** option determines what is written to the file:

Current Object - only the current object, regardless of its type, is written to the file

All Elements - all existing elements are written out to a single file

All Blocks - all existing blocks are written out to a single file. Not yet available.

All Grids - all existing grids are written out to a single file. Not yet available.

All Solutions - solution data is written out to a single file. Not yet available.

Also, the user selects from the **File Format** option menu the format of the file to be written out. There are three file format types available: *Formatted*, *Unformatted*, and *Binary*. For descriptions of each of these, see the previous section "File Open window" (p. 22).

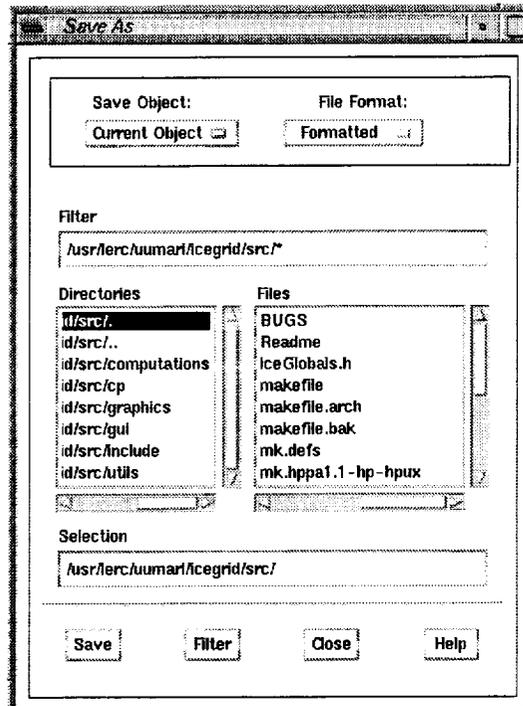


Figure 19. Save As Window

The following controls are used to specify a file where the data will be saved: **Filter**, **Directory**, **Files**, and **Selection**.

Selection - Displays the path and filename of the file you want to write to.

For the full description of each of these controls, see page 23 under the section "File Open window".

Screen Save window

The **Screen Save** window allows the user to save the Graphics Window to a file. The **File Type** option menu determines the type of image file that will be saved: *GIF*, *TIFF*, or *PPM* (portable pixmap). The rest of the controls are used the same way as in the **File Open** and **Save As** windows.

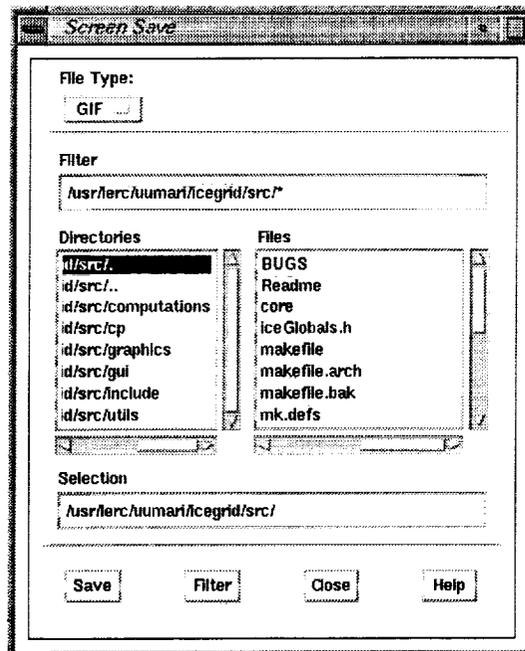


Figure 20. Screen Save Window

Ice Shape Characteristics window

The **Ice Shape Characteristics** window allows the user to probe geometry measurements (such as location, length, arc length, angle, and (X-Xle)/C) using various point selection methods (such as all objects, current object, interpolated, reference airfoil, and arbitrary point). The user can enter the probe information in the Probe Table, and this information can be saved to a file. This window consists of parameters, controls and buttons.

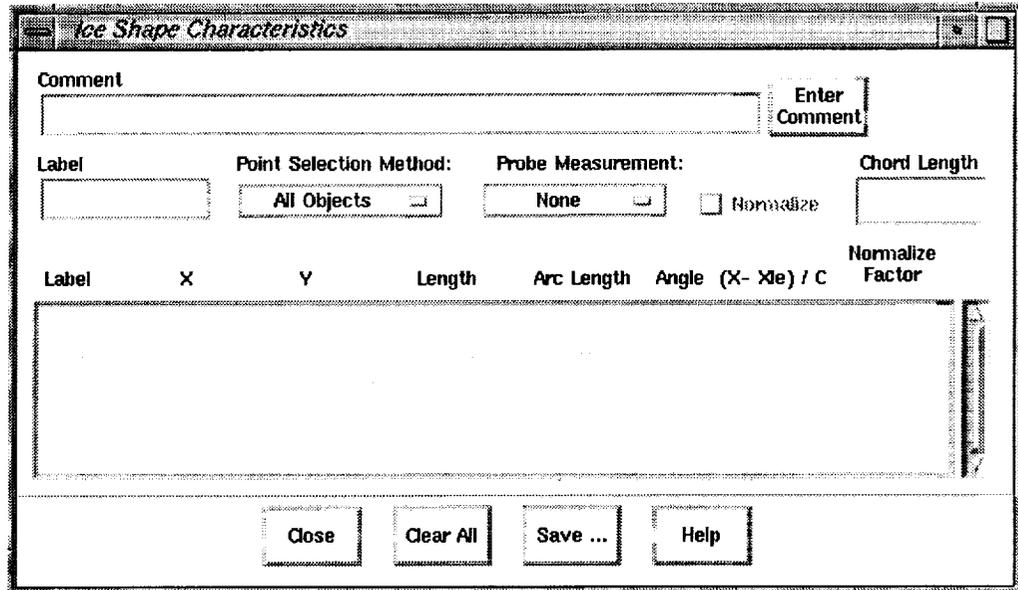


Figure 21. Ice Shape Characteristics Window

Parameters

Comment - Typing a string in this field has no effect until the Enter Comment button is pressed. At that time, the comment is entered on a separate line in the Probe Table.

Label - (up to 12 characters) Typing a string in this field just sets a value; no information is entered into the table until a measurement is made. At that time, this label, along with the measurement is entered into the table. This field may be blank.

Point Selection Method - selects the method used to find points when making measurements; one of: *All Objects*, *Current Object*, *Interpolated*, *Reference Airfoil*, or *Arbitrary Point*.

All Objects - the closest point will be chosen by searching through all the objects.

Current Objects - the closest point will be chosen from the currently-selected object only.

Interpolated - a point will be chosen on a line segment which is between two points of the current element. This option is currently not available.

Reference Airfoil- the closest point on the reference airfoil will be chosen. In order to select this choice, a reference airfoil must have previously been set (menu selection: *Probe-> Set Reference Airfoil*). If the reference airfoil is highlighted (menu selection: *Probe-> Highlight Reference Airfoil*), two additional points will be available to be chosen: the leading edge of the airfoil, or the center of the leading edge circle.

Arbitrary Point - the point chosen does not have to be on an object.

You may change the point selection method at any time, even while in the middle of making measurements. So for example, when measuring length, one endpoint may be chosen using the Current Object method, and the second endpoint may be chosen using the Arbitrary Point method.

Probe Measurement - selects the probe type from the option menu; one of: *Location, Length, Arc Length, Angle, (X-Xle)/C*, or *None*. This determines how the mouse will be used and what type of information will be entered into the Probe Table.

Location - a single point should be selected; its (x,y) coordinates can be entered in the Probe Table.

Length - two points on the boundary of a single object should be selected; the distance between the two points can be entered in the Probe Table.

Arc Length - two points on the boundary of a single object should be selected; the length of the line segments along the boundary between two points on the boundary can be entered in the Probe Table. The selection of the second point will be constrained to be on the same boundary as the first point. Also, since the points must be on a boundary, the *Arbitrary Point* selection method may not be used with this probe type.

Angle - two lines should be selected; the angle (in degrees) between the two lines can be entered in the Probe Table

(X-Xle)/C - a single point should be selected; this value can be entered in the Probe Table. Here X = the x-coordinate of the selected point, Xle = the x-coordinate of the leading edge of the reference airfoil, and C = the chord length of the reference airfoil

None - no probing type is active

Normalize - selects whether or not normalization will be performed when calculating location and length. The data is normalized by dividing by the chord length. This normalization factor (i.e., the chord length) will be entered into the Probe Table. Because the chord length is needed for normalized measurements, a reference airfoil must be set in order to be able to choose this option.

Chord Length - displays the chord length of the reference airfoil when a reference airfoil has been set. However, this field will only be used in calculations when the **Normalize** box is checked.

Controls

Probe data are calculated and entered into the table by using the mouse. The particular Probe Measurement selected determines how the mouse is used. But in general, the left and middle mouse buttons are used to select points or endpoints of lines, and the measurement information will be displayed temporarily in the **Information Area** of the Main Screen. Then when the right mouse button is pressed in the graphics window, the measurement information is entered into the Probe Table. The use of the mouse button clicks will be described in the **Instructions** scrollable text area in the **Graphics Window Mode** section of the Main Screen.

Buttons

[Enter Comment] - Enters the text specified in the comment field into the Probe Table as a separate line.

[Close] - Closes the window

[Clear All] - Clears all entries in the Probe Table.

[Save ...] - Saves the data in the Probe Table to a file. A file selection window will open to allow you to specify the output file.

[Help] - Displays help information for the **Ice Shape Characteristics** window.

Discretize Subcurve window

The **Discretize Subcurve** window allows the user to discretize the selected subcurve of the current object. The new discretized points are displayed as blue crosses overlaid on the graphics display. This window consists of parameters and buttons.

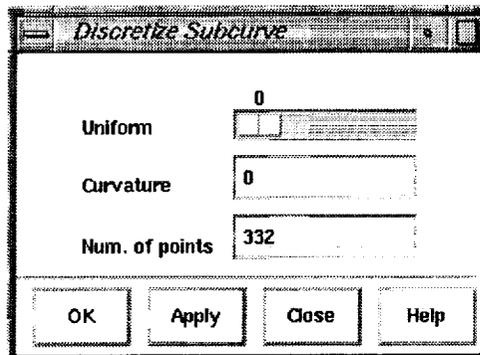


Figure 22. Discretize Subcurve Window

Parameters

Uniform - an integer value in the range [0,10]. A value of 0 makes no change to the original distribution, while a value of 10 distributes the points on the subcurve uniformly. Change this parameter by sliding the horizontal scroll bar.

Curvature - an integer value greater than or equal to zero. A greater number will cluster points more tightly in areas of high curvature. Change this parameter by typing an integer in the text box and pressing <Enter>.

Number of points - the number of points in the discretized subcurve; an integer value greater than or equal to two. Change this parameter by typing the number of desired points in the text box and pressing <Enter>.

Buttons

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the curve, replacing the old points with the newly discretized points.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the **Discretize Subcurve** window.

Change Free Form Subcurve window

The Change Free Form Subcurve window allows the user to change the shape of the selected subcurve by using control points. The new point locations are displayed as blue crosses overlaid on the graphics display. This window consists of parameters, controls and buttons.

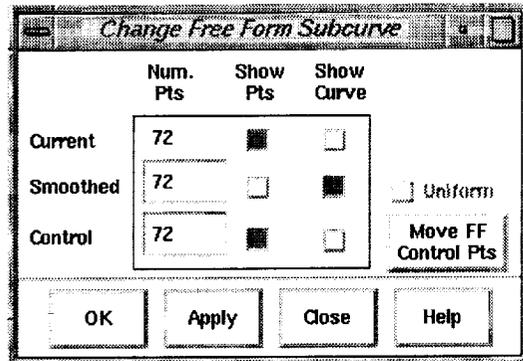


Figure 23. Change Free Form Subcurve Window

Parameters

Number of Smoothed Points - this textfield contains the number of smoothed points to be calculated for the new curve; an integer value greater than or equal to 3 must be used. Change this parameter by typing an integer in the text box and pressing <Enter>.

Number of Control Points - this textfield contains the number of control points to be used; an integer value greater than or equal to 3 must be used. Change this parameter by typing an integer in the text box and pressing <Enter>.

Controls

Show check boxes - allows you to select what will be shown in the graphics display while changing the free form subcurve. Points and/or curves for the current subcurve, the smoothed (modified) subcurve, and the control net can be displayed.

[Move FF Control Pts] - Sets the graphics mode to Move FF Control Points. While in this mode, you may move the control points, thereby changing the shape of the subcurve. Instructions for moving the control points will be displayed in the **Instructions** scrollable text area in the **Graphics Window Mode** area of the main screen.

Uniform - this option is currently not available.

Buttons

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the curve, replacing the old points with the new points.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the **Change Free Form Subcurve** window.

Tanh Redistribution window

This window allows the user to redistribute the points of the selected subcurve of the current object using a hyperbolic tangent redistribution method. The new point locations are displayed as blue crosses overlaid on the graphics display. This window consists of parameters and buttons.

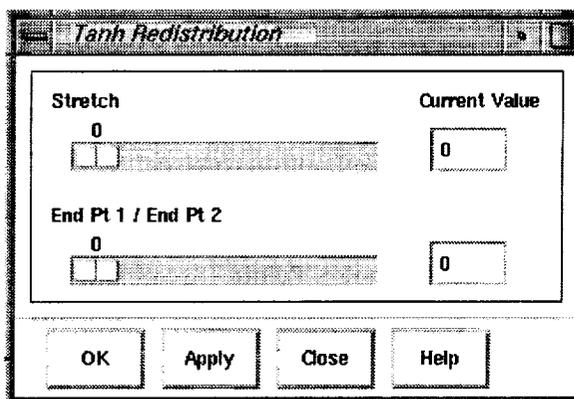


Figure 24. Tanh Redistribution Window

Parameters

Stretch - the amount of stretch to apply; an integer value in the range [0,100]. Change this parameter by sliding the horizontal scroll bar or by typing an integer in the text box and pressing <Enter>.

EndPt1/EndPt2 - indicates the endpoint toward which subcurve points will be clustered; an integer value in the range [0,100]. A value of 50 will stretch points equally towards both endpoints. Change this parameter by sliding the horizontal scroll bar or by typing an integer in the text box and pressing <Enter>.

Buttons

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the curve, replacing the old points with the redistributed points.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the *Tanh Redistribution* window.

Online Help

The Smagglce on-line help uses Netscape to display the help files, which are stored in HTML format. If you have trouble displaying on-line help from Smagglce, make sure Netscape is available on your workstation, and check to make sure the environmental variable `WEBBROWSER` was set correctly in the file `bin/runsmagg` in the `smagglce` directory. You may also view the help files independently of Smagglce by pointing your browser to the file `help/index.html` in the `smagglce` directory.

This chapter will step you through the some general tasks in Smagglce, and then present several scenarios: view modification, boundary modification, and probing.

Note: If you have installed Smagglce in a directory other than `$HOME/smaggice`, modify all the pathnames in the tutorial accordingly.

General tasks

This section will walk you through some general tasks that you will need to be able to do whenever you use Smagglce.

Start Smagglce

Start up Smagglce by executing the `runsmagg` script, which can be found under the `bin` subdirectory of `smaggice`. Enter it at the shell prompt, making sure to specify the full path name. For example:

```
$HOME/smaggice/bin/runsmagg
```

Read geometry

You will read in a three-element airfoil which is stored in a formatted element file. Select from the main menu: *File->Open*

In the *File Open* window,

- Select *Element Boundary* as the **File Type**.
- Select *Formatted* as the **File Format**.
- Read the file: `3elem.all.geo` from the directory `$HOME/smaggice/geometry`.
- Close the window.

Select current object

SmagglIce performs operations on the current object. You may select the current object using one of these methods:

- Select from the main menu: *Boundary->Switch Object*. Do this several times to switch between the three objects.
- Use the hot key <Ctrl>W. You may do this several times in succession to cycle among objects.
- Type an object number directly into the **Object #** text box in the **Current Object Info** area of the main screen. Try entering 2 to switch to object number 2.

Notice that the selected object is displayed in red, and the non-selected objects are displayed in green. Also notice the information that is displayed in the **Current Object Info** area on the left portion of the main screen.

Get on-line help

On-line help is available and displayed through your web browser.

- To request general help from the main window, select from the main menu, *Help->Online Help...*
- As you start using other SmagglIce windows, you will see that specific help may be accessed by pressing the **[Help]** button at the bottom of each of those windows.

Clear all

At times you will want to clear all graphics and data, and return SmagglIce to its initial state.

- From the main menu, select: *Edit->Clear All*.

Exit

To exit SmagglIce,

- From the main menu, select: *File->Extt...*

You will be asked to verify your choice.

- Press **[Yes]** to exit.

Scenario 1 - View modification (geometry transformation)

This section will explain how to perform geometry transformations to change the view you have of the geometry. You will be using the seven widgets across the top of the screen to do this.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the formatted element file: `3elem.all.geo` from the directory `$HOME/smaggice/geometry`.

Graphics Mode transformations

The three buttons on the top left of the graphics window (**[Translate]**, **[Scale]**, and **[Area Zoom]**) set the Graphics Window mode so that mouse movements in the graphics window will change the view. When you select any one of these, you will notice that the mouse cursor changes to indicate that you are in a special view manipulation mode.

- Press the **[Translate]** button (notice that it turns blue, to indicate that the Translate mode is active), then follow the instructions in the lower left corner of the main screen to move the geometry around.
- Press the **[Scale]** button. This will switch you to Scale mode and allow you to enlarge or reduce the image.
- Press **[Area Zoom]**. This allows you to draw a box around an area that will be enlarged to fill the screen.
- To exit any of these modes, click on the button again. The button will turn gray to indicate that the mode is not active, and the mouse cursor will return to its previous shape.

Immediate transformations

The four sets of buttons on the top right of the graphics window (**[Full View]**, **[Zoom In]**, **[Zoom Out]**, and **Translate arrows**) immediately change your view of the geometry.

- Press **[Full View]** to reset the view to include all of the geometry.
- Press **[Zoom In]** or **[Zoom Out]** to scale the geometry up or down incrementally.
- Press one of the **Translate arrows** to move the geometry up, down, left, or right by the specified window percentage. You may also change the percentage by typing a new value in the center box of this widget.

Scenario 2 - Boundary modification

This section will show you how to select and modify subcurves.

Startup

- Start SmagIce (or select *Edit->Clear All*, if already running a session).
- Read the formatted element file: `clean+2ice.geo` from the directory `$HOME/smaggice/geometry`.
- Notice that there are three objects: the full clean airfoil (a closed element) and two ice shapes (open elements). Make sure that object 1 is selected.

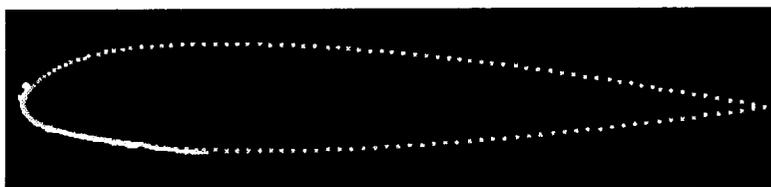


Figure 25. Geometry file: `clean+2ice.geo`; object 1 selected.

Select subcurve

Initially, the selected subcurve for an element is the entire curve. You will usually want to select only part of the curve to work with.

- From the main menu, select: *Boundary->Choose Subcurve*.
- Your cursor will change to indicate that you are in a special mode for selecting points. The instructions in the lower left corner of the screen will tell you how to select the endpoints of the subcurve. As you select the endpoints of the subcurve, notice how the information in the upper left corner of the screen changes. Also note that the points on the subcurve are displayed in red, while the points not on the subcurve are displayed in orange.
- Select the upper surface of the airfoil as the current subcurve. This will be between point indices 1 and 83. You may find it easier to select specific points by using the mouse to click near the point, then using the arrow keys to set the exact point. The left and right arrow keys can be used to change the index of the most recently selected subcurve endpoint.
- To exit the Choose Subcurve mode, press the right mouse button.

Hyperbolic tangent redistribution

This allows you to redistribute the points in the selected subcurve. This tool will let you concentrate the distribution of points near the leading and/or trailing edge(s).

- From the main menu, select: *Boundary->Tanh Redistribution...*
- Notice that two sets of points are displayed: the current points as red dots and the modified points as blue crosses.
- You may change the amount of stretch and how the stretching is distributed between the two endpoints by using the sliders in this window. You can also change a value by typing a number in the appropriate text entry area and pressing <Enter>. Set the **Stretch** value to 100 and the **EndPt1/EndPt2** value to 50.
- If you would like to replace the current points with the modified points, press **[Apply]**. To close the window without making the changes permanent, press **[Close]**. Pressing **[OK]** will apply the changes and close the window all at once.

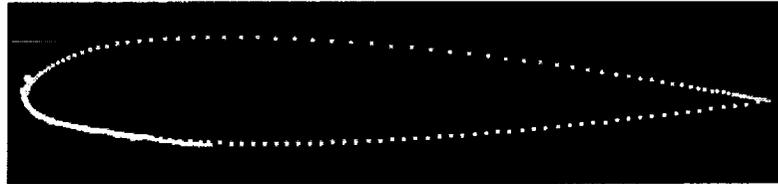


Figure 26. Redistributed points on upper surface of airfoil.

Discretize subcurve

This allows you to change the number of points in the subcurve and how they are distributed.

- Switch to object 2, and zoom in on the area at the leading edge of the airfoil (Figure 27). Select indices 1 and 56 as the endpoints of the subcurve by using the *Boundary->Choose Subcurve* menu selection.
- From the main menu, select: *Boundary->Discretize Subcurve...* If this menu selection is grayed out, it may be that you are still in the Choose Subcurve mode. (Follow the instructions in the lower left corner of the main screen, and click the right mouse button to exit that mode.)
- Again, the current points are displayed as red dots while the modified points are displayed as blue crosses.
- To change the **Uniform** parameter, drag the slider. To evenly distribute the points, set this to the maximum value of 10.
- Change the number of points in the subcurve to 100, by typing that value in the text field and pressing <Enter>.

- Press [**Apply**] to make the changes permanent.
- You may want to concentrate the distribution of points near areas of high curvature. Set the **Uniform** parameter back to 0, then type a value of 2 or 3 in the **Curvature** text field and press <Enter>.
- Make the changes permanent, or discard the changes the same way you did in the *Tanh Redistribution* window.

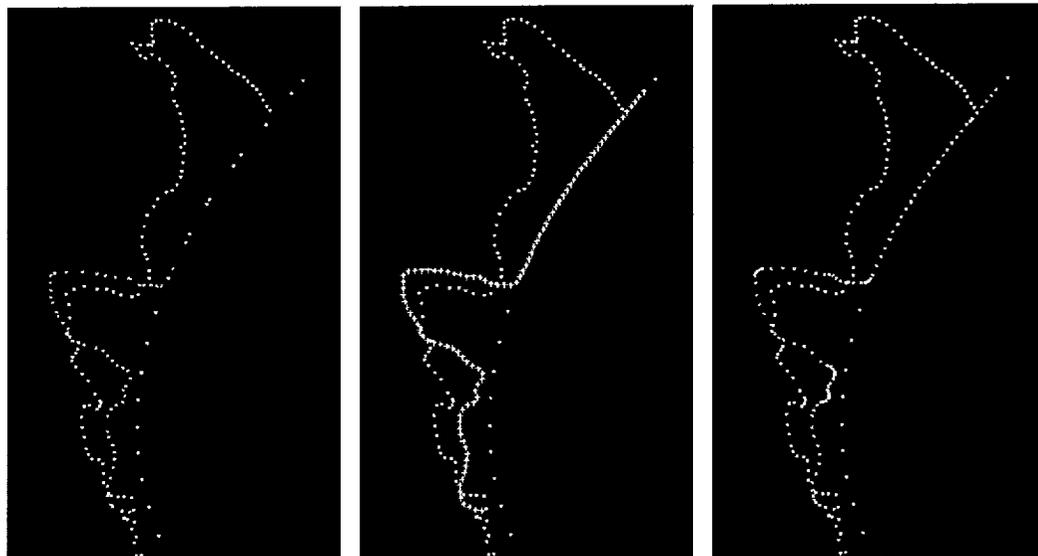


Figure 27. Left to right: original distribution; uniformly discretized to 100 points; discretized by curvature.

Change subcurve using free form method

This allows you to smooth the subcurve and modify the subcurve by moving control points that define its shape.

- Make sure the view is zoomed into the area at the front of the airfoil (Figure 28).
- Switch to object 3 and select indices 1 and 112 as the endpoints of the subcurve. (Remember to exit Choose Subcurve mode when you are done.)
- From the main menu, select:
Boundary->Change Free Form Subcurve...
- The **check boxes** in this window will allow you to display the current points, the smoothed (modified) points, and the control points, as well as the lines connecting those points. Try turning these on and off.
- Increase the number of **Smoothed** points to 150 by typing that value in the text box and pressing <Enter>.

- Decrease the number of **Control** points to 40 by typing that value in the text box and pressing <Enter>. This has the effect of smoothing the subcurve.
- You may also modify the curve by moving the control points. Press the **[Move FF Control Pts]** button. You are now in the Move FF Control Points mode. Follow the instructions to move control points. To exit this mode, press the right mouse button.
- Make changes permanent, or discard the changes the same way you did in the *Tanh Redistribution* window.

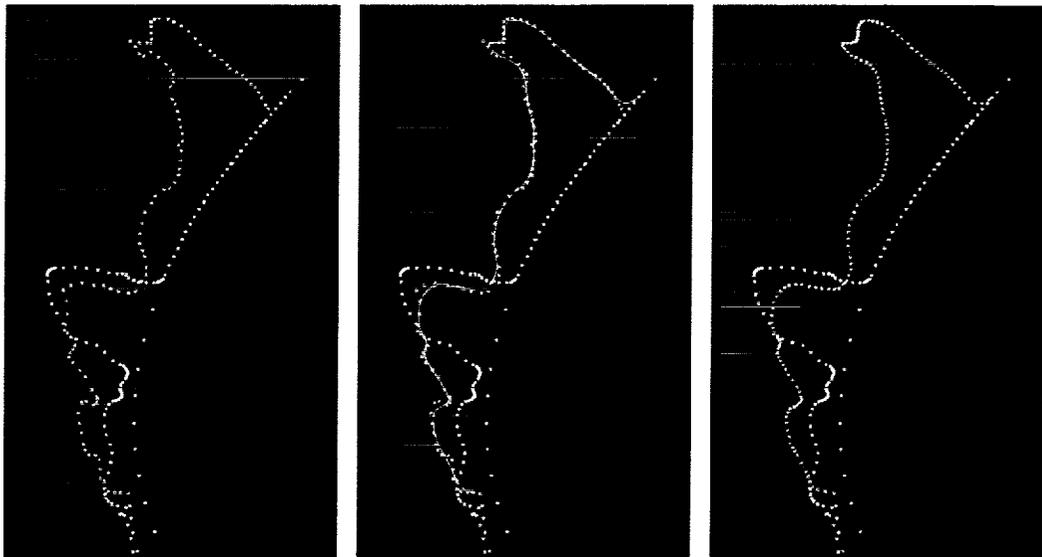


Figure 28. Left to right: original points; curve smoothed using 40 control points (control points not shown); new curve with 150 points.

Save modified geometry

After making these changes to the geometry, you may want to save the geometry to a new file.

- From the main menu, select: *File->Save As...*
- Under the **Save Object** option menu, select *All Elements*. Type the name of the new file in the **Selection** text box and click **[Save]**.
- You may want select *Edit->Clear All* and then read in this new file to verify that the changes were saved.

Scenario 3 - Probing

This section will step you through the process of making measurements of ice shapes, i.e., probing.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the formatted element file: `clean+3ice.scaled.geo`. This file contains 4 closed elements: a clean airfoil and three iced airfoils.
- Zoom in to the area at the leading edge of the airfoil.
- Select object 2 to be the current object.

Display point coordinates

You can display the coordinates of points in the current object. When you select a point, both its index and its (x,y) coordinates are displayed in the **Information** area of the main screen.

- From the main menu, select: *View->Display Point Coordinates*
- Follow the instructions in the lower left corner of the screen to select points and display their coordinates in the **Information** area. These coordinates are for immediate reference only. The following steps will show you how to keep a record of point locations, as well as other types of probing information.
- To exit Display Point Coordinates mode, press the right mouse button.

Select reference airfoil

For some probing measurements, such as $(X - X_{le}) / C$, a clean airfoil must be identified as a reference, since the chord length C is determined from the clean airfoil. The chord length can also be used to normalize measurements such as length. In order to choose these calculations, you must first identify the clean airfoil so that the chord length can be determined.

- Select object 1 (the clean airfoil).
- From the main menu, select: *Probe->Set Reference Airfoil*.
- You may want to highlight the clean airfoil by selecting from the main menu: *Probe->Highlight Reference Airfoil*. Notice that there are two additional points marked with purple crosses: the leading edge point, and the center of the leading edge circle. During probing, you may select these points as you would others. (Figure 29)

Probe measurements

- From the main menu, select: *Probe->Ice Shape Characteristics*.
- Comments may be entered at any time into the Probe Information Table. Type "Probing Tutorial" in the comment text area, and press the <Enter> key or the [Enter Comment] button.

Location

Make a location measurement:

- Select *Location (X,Y)* from the **Probe Measurement** option menu. Follow the instructions in the **Instruction** area of the main window to select a point. Now select a different point. Notice how the probe information is displayed in the **Information** area of the main window. However, nothing is entered into the Probe Table until you press the right mouse button. Now enter the location into the Probe Table by pressing the right mouse button.

Length

You will next make a measurement of normalized length:

- Change the **Probe Measurement** to *Length*.
- You are currently able to choose points from all objects. Now change the **Point Selection Method** by selecting *Current Object* from that option menu. This will limit the points which may be selected to those on the current object only.
- Click on the **Normalize** check box to measure normalized length. This will normalize all measurements by dividing them by the chord length, which in this case is 8.000225.
- Type the string "LE circ rad" into the **Label** text field, indicating that this will be a measurement of the radius of the circle inscribed in the leading edge of the airfoil. This label will be entered into the Probe Table when you enter the measurement.
- Follow the instructions to select two endpoints: one being the leading edge of the airfoil, the other being the center of the leading edge circle (both marked in purple crosses). Enter the measurement into the Probe Table. Note that if the reference airfoil is not highlighted, you will not be able to select these two points.

Glyphs

You will have noticed that after measurements are entered into the Probe Table, symbols (or glyphs) such as points and lines are overlaid on the geometry to indicate where the measurements were made. You may want to turn off the display of these glyphs by selecting from the main menu: *Probe->Display Glyphs*.

Arc length

Arc length measures the sum of the lengths of the line segments along a boundary between two points on that boundary.

- Set the **Probe Measurement** to *Arc Length*, and turn **Normalize** off.
- Select the two endpoints: one being the leading edge of the reference airfoil, the other being the location where the ice attaches to the airfoil at the upper surface.
- Change the **Label** to "ice limit", and enter the measurement into the Probe Table.

Angle

To measure an angle, you will need to mark two lines between which the angle will be measured. Normalizing this measurement has no effect.

- Set the **Probe Measurement** to *Angle*.
- Following the instructions in the **Instruction** area, set the endpoints of the first line: the center of the leading edge circle and the leading edge point itself.
- For the second line, set the first endpoint to again be the center of the leading edge circle. For the second endpoint, set the **Point Selection Method** to *All Objects*, and select the tip of the uppermost ice horn.
- Change the **Label** to "upper horn", and enter the measurement into the Probe Table.

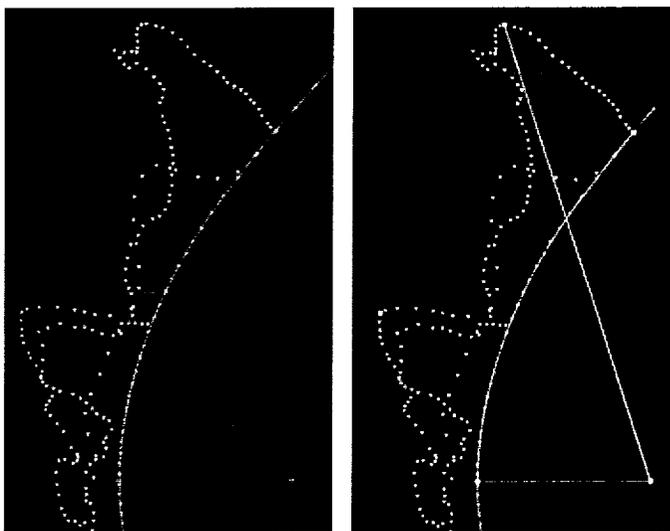


Figure 29. Left: highlighted reference airfoil with markers at leading edge and center of leading edge circle; Right: glyphs marking measurements of location, length, arc length, angle, and $(X-X_{le})/C$.

(X-X_{le})/C

This measurement calculates the value $(X-X_{le})/C$, where X is the x -location of the point selected, X_{le} is the x -location of the leading edge, and C is the chord length of the reference airfoil.

- Set the **Probe Measurement** to $(X-X_{le})/C$.
- Set the **Label** to "ice tip", select the point on the tip of the uppermost ice horn, and enter the measurement into the Probe Table.

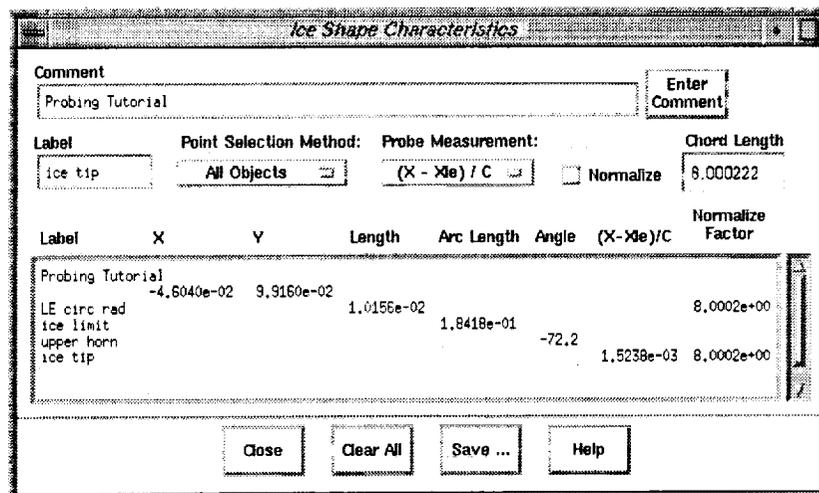


Figure 30. Ice Shape Characteristics window with entries in the Probe Table.

Save probe information

At this point, you may want to save the probe information to a file.

- In the **Ice Shape Characteristics** window, press the [**Save..**] button. This will bring up a subwindow which will allow you to save the Probe Table to a text file.
- You may also save a screen image of the geometry with the lines and points of your measurements displayed. First turn glyph display back on by selecting *Probe->Display Glyphs* from the main menu, then select *File->Screen Save....* You may choose to save the image as a TIFF, GIF, or PPM image file.
- To clear the Probe Table and all associated glyphs, press the [**Clear All**] button in the **Ice Shape Characteristics** window.



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13. ABSTRACT (<i>Maximum 200 words</i>) SmaggIce (Surface Modeling And Grid Generation for Iced Airfoils) is one of NASA's aircraft icing research codes developed at the Glenn Research Center. It is a software toolkit used in the process of aerodynamic performance prediction of iced airfoils. It includes tools which complement the 2D grid-based CFD process: geometry probing; surface preparation for gridding; smoothing and re-discretization of geometry. Future releases will also include support for all aspects of gridding: domain decomposition; perimeter discretization; grid generation and modification			
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